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DRAWINGS ATTACHED

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(54) IMPROVEMENTS IN OR RELATING TO FLUID LEVEL DETECTING DEVICES

(71) I, Christopher Ian Arthur Ellis, a British Subject, of 30, Hill Road, Claughton, Birkenhead, Cheshire, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention concerns fluid level detecting and indicating apparatus and particularly concerns a level detecting and indicating device which does not require to be in direct electrical contact with the fluid.

The invention also concerns a level detecting device which additionally detects and indicates an interface between two dissimilar fluids.

One known form of level detecting device comprises a pair of vertically displaced electrodes mounted in the fluid container. However, such a device can only be used with a fluid which can conduct electricity, since the change in electrical resistance which occurs when the electrodes become immersed in such a fluid, is used to indicate when the fluid level reaches the upper electrode. Furthermore such an arrangement cannot be used in applications where electrolytic decomposition of the fluid must be avoided or where there is any possibility of fire hazard.

An alternative, also known level indicator has been designed for use with the sight tube, characteristic of many types of fluid container. In this alternative indicator a pencil beam of light is directed so as to pass through the sight tube and impinge on a light sensitive device such as a photo-electric cell. The variation in light transmitted through the sight tube and resulting change in output of the light sensitive device when the sight tube is full or empty of fluid can be used to indicate when the fluid level exceeds or falls below the level determined by the sight tube. However, this alternative device suffers from the disadvantage that any discolouration of the fluid or wall of the sight tube will greatly effect the light transmission through the sight tube. Hence ageing and dirt can effect the output from the light sensitive device and give false readings. Furthermore, this alternative type of device cannot be used for clear liquids such as water.

Neither of the above mentioned level indicating devices can detect an interface between two dissimilar fluids and it is therefore, an object of the present invention to provide a level indicating device which does not suffer from the disadvantages of these two known types, and which additionally detects and indicates the presence of an interface between two dissimilar fluids.

According to the present invention a level detector and indicator for indicating when a fluid level or interface reaches a predetermined region in a container comprises electric signal amplifying circuit means having an input and an output, a feed back loop between said output and input to enable oscillation to be maintained in the circuit, a bridge circuit in the feed back loop which prevents feed back when balanced, a capacitive element in each of two of the bridge arms, of which one capacitive element is formed by a first pair of electrodes whose capacitance value varies as the fluid or interface level varies in the container and the other capacitive element is formed by a second pair of electrodes whose capacitance also varies as the fluid or interface level varies in the container, the two pairs of electrodes being vertically separated and adjusted so that the bridge is balanced when the fluid or interface level lies above the upper electrode pair or below the lower electrode pair but is unbalanced, thereby allowing oscillation, when the level registers with either of the electrode pair or therebetween, and further circuit means to produce an output signal indicative of oscillation of the circuit.

Conveniently the electrodes may be positioned around a sight tube mounted on the container. Alternatively they may be mounted on the inside wall of the container so that when the fluid reaches and exceeds

the predetermined region, the two electrodes are totally immersed in the fluid. In this latter arrangement at least one of the electrodes would require to be coated by an impervious insulating material which has no chemical reaction with the fluid within the container.

In an arrangement embodying the invention, the bridge will therefore be balanced if the fluid level is below the lower electrode pair. If however, the fluid level rises so that fluid is present between the lower two electrodes while air is present between the upper two electrodes the two capacitors will have a different value of capacitance and the bridge will not be balanced and oscillation will therefore occur. If the fluid level continues to rise so that fluid exists between both the lower pair and upper pair of electrodes and the two capacitors then have the same capacitance, the bridge will be balanced thereby preventing oscillation.

Similarly, if an interface between two dissimilar fluids (the two fluids not being miscible and having different dielectric strengths) lies vertically between the upper pair of electrodes and lower pair of electrodes, the capacitance of the upper pair of electrodes will be different from that of the lower pair of electrodes. The bridge will thereby be unbalanced and oscillation will be maintained. However, should the interface rise (or fall) so that the space between the two pairs of electrodes is occupied by the same fluid, the two capacitors will have the same capacitance and the bridge will be balanced, thereby preventing oscillation.

In a bridge circuit in which the two capacitive elements have a common junction one of the electrodes from each pair will be at the same potential and in accordance with a preferred embodiment of this invention the electrode assembly can be formed by three electrodes, one large common electrode and two smaller electrodes separated from each other and from the common electrode. Furthermore, in such an arrangement where the fluid container is a metallic tank or a vessel of electrically conductive material, the third electrode can be dispensed with and the two sensing electrodes mounted symmetrically relative to the inside surface of the container wall, both said electrodes being electrically insulated from the container and from each other. The conductive container then forms the third common electrode and the capacitance of the two capacitive elements thereby formed is the capacitance between each electrode and the container. In certain cases this is of great advantage since larger values of capacitance for the two separate capacitive elements may thereby be obtained.

Balancing capacitors of adjustable capacitance may be connected in parallel with the electrode pair to compensate for any differences in capacitance therebetween.

The invention will be described further by way of example with reference to the drawing accompanying the Provisional Specification in which:—

Fig. 1 is a circuit diagram illustrating the principal of operation of a level and interface detector constructed in accordance with the invention,

Fig. 2 is a circuit diagram of one embodiment of the present invention,

Fig. 3 illustrates diagrammatically the electrode assembly for a probe for use in the device of Fig. 2, mounted on a sight tube,

Fig. 4 illustrates a similar probe in which the level of fluid in the sight tube (and therefore the container) is in a position such that a differential capacitance exists between the various electrodes, and

Fig. 5 illustrates a similar electrode assembly in which an interface between two dissimilar (and non-miscible) fluids occupies a similar position to the level of the fluid in the tube of Fig. 4, thereby also producing a differential capacitance between the various electrodes.

Fig. 1 of the drawings illustrates a theoretical circuit comprising a high gain amplifier A the output of which is applied to the input of a frequency determining network and phase splitting device B. The phase splitting stage supplies two outputs which are symmetrical about a constant reference potential such as earth and these two outputs are fed back to the input of the amplifier A by means of two capacitive elements C1 and C2. The two outputs from the phase splitting device B and the two capacitive elements C1 and C2 together form a bridge circuit.

It will be appreciated that if the capacitance of C1 is the same as the capacitance of C2, the two feedback signals (which are phase inverted with respect to one another) cancel out at the input of the amplifier and no net feedback signal appears at the input to the amplifier A If however, the capacitance of C1 varies relative to the capacitance of C2 so that a net positive feedback signal appears at the input to the amplifier A, oscillation will occur at a frequency determined by a frequency determining network in the circuit B. Although the circuit diagram of Fig. 1 serves to illustrate the theoretical basis on which a device according to the present invention is constructed, a level indicator constructed strictly in accordance with Fig. 1 would suffer from many disadvantages. Accordingly, the practical circuit for a device embodying the invention, is shown in Fig. 2 of the drawing in which it will be seen that the output from a high gain amplifier A is applied to the centre tap of a coil having an inductance L which is connected in parallel with a capacitor C. These two

components constitute a parallel resonant circuit and the coil L forms the primary of a transformer the secondary of which is magnetically coupled to the coil L and comprises a winding having an inductance Lc. This secondary winding Lc is connected in the input circuit of the amplifier A. The ends of the coil L are additionally connected via two capacitive elements C1 and C2 respectively to earth. Since the amplifier output is supplied between the centre tape of the coil L and earth the output signal currents from the amplifier A flow in opposite directions through the coil L and through the two capacitive elements C1 and C2 to earth. If the capacitance (and therefore reactance) of C1 and C2 are equal, the oppositely directed signal currents in the coil L are equal in magnitude and cancel each other out, thereby producing a zero net magnetic field. In consequence, no EMF is induced in the coupling winding Lc and no feedback signal is applied to the input of the amplifier A.

If the capacitance of one of the capacitive elements C1, C2 varies, so that a positive feedback signal is induced in the coupling coil Lc of the transformer L/Lc a positive feed back signal is applied to the input of the amplifier A and oscillation will be maintained at a frequency determined by the resonant frequency of the parallel tuned circuit LC.

In order to indicate when the circuit is oscillating and when the circuit is not oscillating an output signal is derived from the output of the amplifier of Fig. 2. After detecting and amplifying this signal a DC signal is obtained having one level corresponding to oscillation and another to non-oscillation of the circuit. This DC signal can be used to operate an indicator such as a bell or visual alarm when the circuit changes from a state of non-oscillation to a state of oscillation.

The practical circuit of Fig. 2 is considerably superior to the theoretical circuit of Fig. 1 since one side of the capacitive elements C1 and C2 is connected to earth whereas in the theoretical circuit, the common junction of the two capacitive elements C1 and C2 is connected to the high impedance input terminal of a high gain amplifier. This latter arrangement is extremely susceptible to hum pickup and stray capacitance whereas by earthing one side of the capacitive elements C1 and C2 as in the practical realization of the circuit in Fig. 2, and by inductively coupling the input circuit of the amplifier to the tuned circuit, many of these difficulties are overcome.

Since two of the electrodes of the two capacitive elements C1 and C2 are connected to a common electrical point—which in the case of the practical embodiment of Fig. 2 is at earth potential, it is possible to provide the two capacitive elements by the use of only three electrodes. Such an arrangement is shown in Figs. 3 to 5 inclusive where it will be seen that the two electrodes which would be connected together electrically are in fact formed as a single electrode 10 and the other two electrodes 12, 14 are mounted opposite the common electrode 10 and vertically displaced relative to one another. In the arrangement illustrated in Figs. 3 to 5 the electrodes are shown in conjunction with a sight tube 16, only a portion of which is shown in the Figs. for the sake of convenience. The vertical position of the electrodes is such as to straddle the height at which it is wished to monitor the fluid level or interface between the two dissimilar fluids. For example, in an automated cellar for a hotel the vertical position of the electrodes would correspond to the minimum height to which the alcoholic beverage in the container (not shown) is to be allowed to fall. The level of the fluid in the container (not shown) is indicated by the corresponding level of fluid in the sight tube 16 and in Figs. 3 and 4 of the drawing this level is indicated by the reference numeral 18. In Fig. 3 of the drawings the fluid level 18 is shown below the electrode assembly so that (apart from the wall of the sight tube which in practice is made from glass) the space between the electrodes is entirely filled by air. The electrode assembly is so constructed that the capacitance between the electrode 12 and the common electrode 10 is identical to the capacitance between the electrode 14 and the common electrode 10 when the various electrodes are separated by material having the same dielectric strength.

Should the level 18 of the fluid in the sight tube 16 rise to the position shown in Fig. 4 of the drawings, the capacitance between the electrode 14 and the common electrode 10 differs from the capacitance between electrode 12 and electrode 10. By arranging that this change in relative capacitance brings about positive feed back in the circuit of Fig. 2, this circuit will be set into oscillation which will only cease if the level 18 rises well above the electrode 12 or drops again well below the electrode 14.

It will be appreciated that the actual value of capacitance of the capacitive elements C1 and C2 is immaterial if they are both equal. Furthermore the bridge circuit formed by the two capacitors and the inductor L will be balanced equally well if the sight tube is completely filled with fluid or is completely empty of fluid. The out of balance condition however will occur if the level of the fluid occupies a position substantially as indicated in Fig. 4.

The device of Fig. 3 will also serve to indicate the vertical position of an interface 20 between two dissimilar fluids 22, 24 if the dielectric constant of the two fluids is

different. Such an interface 20 is shown in Fig. 5 where the position shown will cause the capacitance of electrode 12 (with respect to electrode 10) to be different from the capacitance of electrode 14 with respect to electrode 10). This causes unbalance of the bridge circuit and consequent oscillation. If however the interface 20 is well above or well below electrodes 12 and 14 respectively the capacitance of the two capacitive elements C1 and C2 is identical and the bridge will once again be balanced.

It will be apreciated that the ability to be able to measure the vertical position of an interface between two dissimilar fluids is of great importance when dealing with large capacity petrol tanks as used by petrol stations and garages. For various reasons water enters these tanks and since oil is less dense than water, the water sinks to the bottom of the tank and the petrol or oil tends to float on the water layer. In order that the water is not sucked into the fuel pump when oil or petrol is being drawn from the tank, it is essential that the height of the water layer in the tank does not exceed a given point. By arranging an electrode assembly 10, 12, 14 in the tank at this critical vertical height and connecting an alarm bell to the output from the device a warning can be given when the interface between the water and petrol reaches the critical height.

It will be appreciated that, whilst the fluid level and interface detector herein described is eminently suited for use with fluids of liquid form, it may nevertheless be used with fluids of dry powder form or slurries or suspensions.

WHAT I CLAIM IS:—

1. A level detector and indicator device for indicating when a fluid level or interface reaches a predetermined region in a container, comprising electric signal amplifying circuit means having an input and an output, a feed back loop between said output and input to enable oscillation to be maintained in the circuit, a bridge circuit in the feed back loop which prevents feedback when balanced, a capacitive element in each of two of the bridge arms, of which one capacitive element is formed by a first pair of electrodes whose capacitance value varies as the fluid or interface level varies in the container, and the other capacitive element is formed by a second pair of electrodes whose capacitance also varies as the fluid or interface level varies in the container, the two pairs of electrodes being vertically separated and adjusted so that the bridge is balanced when the fluid or interface level lies above the upper electrode pair or below the lower electrode pair but is unbalanced, thereby allowing oscillation when the level registers with either of the electrode pair or therebetween, and further circuit means to produce an output signal indicative of oscillation of the circuit.

2. A device as claimed in claim 1 in which the pair of electrodes are mounted on a sight tube carried by the container.

3. A device as claimed in claim 1 in which the pairs of electrodes are mounted on the internal face of the container wall and at least one of the electrodes of each pair is completely coated by an impervious insulating material which has no chemical reaction with the fluid within the container.

4. A device as claimed in claim 3 in which one electrode of one pair is formed in common with one of the electrodes of the other pair.

5. A device as claimed in claim 4 in which the container is made of electrically conductive material and comprises the large common electrode.

6. A device as claimed in any of claims 3 to 5 in which balancing capacitors of adjustable capacitance value are connected in parallel with each of the two electrode pairs to compensate for any difference in capacitance therebetween.

7. A level detector and indicator device constructed, arranged and adapted to operate substantially as herein described with reference to and as illustrated in Fig. 1 of the drawings accompanying the Provisional Specification.

8. A level detector and indicator device constructed, arranged and adapted to operate substantially as herein described with reference to and as illustrated in Fig. 2 of the drawings accompanying the Provisional Specification.

9. An electrode assembly in a device as claimed in any of claims 1 to 6 constructed substantially as herein described with reference to and as illustrated in Figs. 3 to 5 of the drawing accompanying the Provisional Specification.

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1213128 PROVISIONAL SPECIFICATION
1 SHEET This drawing is a reproduction of the Original on a reduced scale

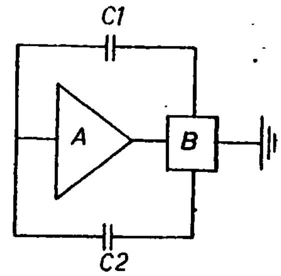

FIG.1

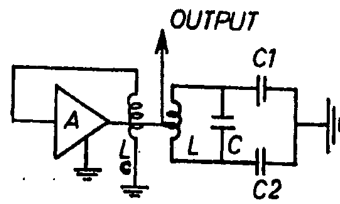

FIG.2.

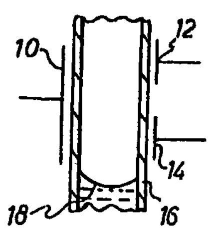

FIG.3.

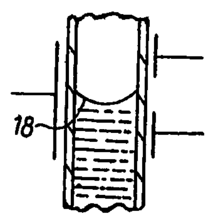

FIG.4.

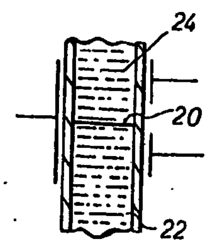

FIG.5.